First results from the ALICE Experiment

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on behalf of the ALICE Collaboration
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• ALICE run 2009-2010

• Detector performance

• First physics results

• A taste of other analyses in advanced stage

• Outlook / Conclusion
Detector configuration

- ITS, TPC, TOF, HMPID, MUON, V0, To, FMD, PMD, ZDC (100%)
- TRD (7/18)
- EMCAL (4/12)
- PHOS (3/5)
  - at nominal T (-25 C)
- HLT (60%)
Trigger configuration (so far)

- based on interaction trigger reading all detectors:
  - SPD (min bias) or Vo-A or Vo-C
  - at least one charged particle in 8 pseudorapidity units
- and single-muon trigger reading MUON, SPD, Vo, FMD, ZDC:
  - single muon, low-pT threshold, in the muon arm in coincidence with interaction trigger
- activated in coincidence with the BPTX beam pickups:
  - ‘bunch-crossing’ with bunches from both sides
  - for control ‘bunch-crossing’ with bunch from side A or C only
  - for control ‘bunch-crossing’ with no bunches
- a fraction of ‘bunch-crossing’ trigger (no condition on trigger detectors)
  - for control
  - to measure relative fractions of single- and double-diffractive events
- HLT in “Mode B” (no event rejection)
ALICE running 2009/2010

- 2009 (0.9 and 2.36 TeV)
  - $\sim 10.3 \mu b^{-1}$
  - $\sim 500 \text{ k min bias}$

- 2010 (till 23/5) (0.9 and 7 TeV)
  - $\sim 2.2 \text{ nb}^{-1}$
  - $\sim 160 \text{ M min bias}$
TPC calibration

- $p_t$ resolution (from cosmics)
- e.g.: at 10 GeV/c ~ 7% (target value ~ 5%)
- see also: J. Alme et al. (ALICE TPC), arXiv:1001.1950 (subm. to NIM)

- now calibrating for
  - internal alignment
  - non-linear effects due to E field distortions (0.2 – 0.3 mm effects)
Material budget (γ conversions)

- use conversions to study material budget
- e.g.: TPC inner field cage (~ 1% $X_0$)

- current description accurate to 5 – 15%
- target: ~ 1% precision
ITS alignment

- SPD: initial alignment with cosmics
  - see K. Aamodt et al. (ALICE), arXiv: 1001.0502 (accepted by JINST)
- SPD: pp data (improvement on the sides)
- SSD: for now global alignment only
  - $\Delta x$ from ladder overlaps: $\sigma \sim 25 \mu m$
  - $\sigma/\sqrt{2} \sim 18 \mu m$ ~ intrinsic resolution
  - internal alignment from survey adequate

- SDD: alignment + drift velocity calib
• e.g.: shoulder in the impact parameter distribution

• due to residual misalignment on the sides
Track impact parameter

- Impact parameter to primary vertex
  - with and without luminous region constraint
Particle identification: TPC

- $dE/dx$ versus momentum:

![Graph showing $dE/dx$ versus momentum and momentum/charge $p/Z$ for different particles at different energies.](image)
Particle identification: TOF

- time resolution already close to nominal

\[ \sigma_{\text{TOF}} = \sigma / \sqrt{2} = 88 \text{ ps} \]
Particle identification: ITS

- $dE/dx$ (SDD, SSD) vs momentum

- electrons visible!
Transition Radiation Detector

- TRD:
  - 7 out of 18 supermodules installed
  - installed supermodules aligned with tracks
  - gain calibration with $\gamma \rightarrow e^+e^- \ K^0_s \rightarrow \pi^+\pi^-$
PHOS, EMCal, HMPID, PMD

PHOS – 3 out 5 modules installed and working at operational temperature – 25 C calibration in progress

EMcal – 4 out 12 modules installed calibration in progress
6 modules prepared for installation

HMPID – fully installed alignment and calibration in progress

PMD – 90% of channels operational

Hits Distribution

Preshower plane

CPV plane

Entries 20596
Muon Spectrometer

- fully installed
- alignment not finalized yet
- Lo trigger on $p_t > 0.5$ GeV
Three papers submitted

- arXiv:0911.5430
  - First proton--proton collisions at the LHC as observed with the ALICE detector: measurement of the charged particle pseudorapidity density at $\sqrt{s} = 900$ GeV

- arXiv:1004.3034
  - Charged-particle multiplicity measurement in proton-proton collisions at $\sqrt{s} = 0.9$ and 2.36 TeV with ALICE at LHC
  → accepted by EPJ C

- arXiv:1004.3514
  - Charged-particle multiplicity measurement in proton-proton collisions at $\sqrt{s} = 7$ TeV with ALICE at LHC
  → accepted by EPJ C
First LHCC Meeting

- $dN_{\text{ch}}/d\eta$ for $|\eta| < 0.5$

- $dN_{\text{ch}}/d\eta$ vs $\eta$

- Data collection

- 284 events (~3.7 authors per event)


The first pp collision candidate shown by the event display in the ALICE counting room (3D view, $r-\phi$ and $r-\eta$ projections), the dimensions are shown in cm. The dots correspond to hits in the silicon vertex detector (SVD, SDD and SSD), the lines correspond to tracks reconstructed using loose quality cuts. From the ALICE Collaboration: First proton-proton collisions at the LHC as observed with the ALICE detector: measurement of the charged particle pseudorapidity density at $\sqrt{s} = 900$ GeV.
\( dN_{ch}/d\eta \)

- Consistent with UA5
  - (only 900 GeV)
- Consistent with CMS
  - (only NSD)
  - does not include charged leptons \( \rightarrow \sim 1.5\% \) difference
Comparison to Monte Carlo

- Pythia D6T and Perugia-o match neither INEL, NSD or INEL>0 at any energy
- Pythia Atlas CSC and Phojet reasonably close with some deviations at 0.9 and 2.36 TeV
- Only Atlas CSC close at 7 TeV
Power law dependence fits well

Significantly larger increase from 0.9 to 7 TeV than in MCs

| Increase in $dN_{ch}/d\eta$ in $|\eta| < 1$ for INEL > 0 | $\sqrt{s}$ | ALICE (%) | MCs (%) |
|----------------------------------------------------------|---------|-----------|---------|
| arXiv:1004.3514                                          | 0.9 $\rightarrow$ 2.36 TeV | $23.3 \pm 0.4^{+1.1}_{-0.7}$ | 15 – 18 |
|                                                          | 0.9 $\rightarrow$ 7 TeV    | $57.6 \pm 0.4^{+3.6}_{-1.8}$ | 33 – 48 |
Multiplicity Distributions

- Distributions in limited $\eta$-regions
- Consistent with UA5
- Fits with one NBD work well in limited $\eta$-regions
- Difference between INEL and NSD in low-multiplicity region

$\sqrt{s} = 0.9$ TeV

Federico Antinori - ALICE - INT 10-2A - Seattle - 24 May 2010
Multiplicity Distributions (2)

- Fits with one NBD work also at 2.36 and 7 TeV

\( \sqrt{s} = 2.36 \text{ TeV} \)

\( \sqrt{s} = 7 \text{ TeV} \)
Comparison to Monte Carlo

- Phojet
  - provides a good description at 900 GeV
  - fails at 2.36 and 7 TeV

- Pythia Atlas CSC
  - fails at 0.9 TeV
  - reasonably close at 2.36 and 7 TeV but deviations around 10–20

- Pythia D6T and Perugia-0 far from the distribution at all energies
Other papers in advanced stage

- Charged particle $p_T$ distribution
- Baryon-antibaryon asymmetry
- Bose-Einstein correlations
- Strangeness production ($K^o, \Lambda, \Xi, \Phi$)
- Identified particles $p_T (\pi, K, p)$
p_T-differential (900 GeV)

- Tsallis fit
- vs generators
$<p_T>$ vs multiplicity (900 GeV)

- vs generators
Baryon-antibaryon asymmetry
Bose-Einstein Correlations

- Hambury Brown – Twiss correlation for identical bosons ($\pi^-$)

- Full analysis ready, under internal approval
  - Vs charged particle multiplicity and $K_T$
K⁰ and Λ

**ALICE Performance**

work in progress

\( p+p \) at \( \sqrt{s} = 900 \text{ GeV} \) (2009 data)

\( q_T \) (GeV/c)

\( |\alpha| = \frac{p_T^+ - p_T^-}{p_T^+ + p_T^-} \)

Counts per MeV/c²

0.2 < \( p_T \) (GeV/c) < 3.0

0.5 < \( p_T \) (GeV/c) < 3.5

M(π⁺π⁻) (GeV/c²)

M(\bar{p}π⁺) (GeV/c²)
ALICE Performance
work in progress

$p+p$ at $\sqrt{s} = 900$ GeV (2009 data)

$cT$ of $K_0^s$

only stat. errors included

$\chi^2$/ndf = 111.4/96
slope = 2.72 ± 0.03 cm
pdg: 2.68 cm

$\chi^2$/ndf = 114.8/97
slope = 7.9 ± 0.1 cm
pdg: 7.89 cm

$\chi^2$/ndf = 75.35/97
slope = 7.7 ± 0.1 cm
pdg: 7.89 cm
K\(^{\pm}\) from kinks

- decay angle v mother’s p
More strange particles....

\[ \phi \rightarrow K^+K^- \]

PDG: 1019.5 MeV

\[ \phi = 1019.6 \pm 0.5 \text{ MeV} \]

\[ \sigma = 5.3 \pm 0.6 \text{ MeV} \]

Kaon-Pion invariant-mass spectrum (like-sign background subtracted)

**Fit parameters:**

- \( m = 895.6 \pm 3.8 \text{ MeV/c}^2 \)
- \( \Gamma = 66 \pm 13 \text{ MeV/c}^2 \)

**PDG parameters:**

- \( m = 896.00 \pm 0.25 \text{ MeV/c}^2 \)
- \( \Gamma = 50.3 \pm 0.6 \text{ MeV/c}^2 \)

2009 data

\( p+p \) at \( \sqrt{s} = 900 \text{ GeV} \)

\( \Xi^- + \Xi^+ \) candidates

\[ (M_{p+p}) = 1.3217 \text{ GeV/c}^2 \]

Gaussian Fit:

\[ \chi^2/\text{ndf} = 23.47/26 \]

\[ M_0 = 1.3218 \pm 0.0002 \text{ GeV/c}^2 \]

\[ \sigma = 2 \text{ MeV/c}^2 \]

ALICE data, \( p+p \) at \( \sqrt{s} = 7 \text{ TeV} \)

\( \Omega^- \) candidates

\[ (M_{p+p}) = 1.6725 \text{ GeV/c}^2 \]

Gaussian+Pol1 Fit:

\[ \chi^2/\text{ndf} = 53.42/44 \]

\[ M_0 = 1.6726 \pm 0.0002 \text{ GeV/c}^2 \]

\[ \sigma = 2.1 \pm 0.2 \text{ MeV/c}^2 \]
Charm!

pp $\sqrt{s} = 7$ TeV, $6.8 \times 10^7$ events, $p_t^0 > 2$ GeV/c

$D^0 \rightarrow K^- \pi^+$

ALICE work in progress
21/05/2010

Mean = $1.868 \pm 0.002$
Sigma = $0.020 \pm 0.002$

Significance (2 $\sigma$) $11.2 \pm 1.3$
S ($2 \sigma$) $522 \pm 60$
B ($2 \sigma$) $1664 \pm 27$

$D^+ \rightarrow K^- \pi^+ \pi^+$
ALICE work in progress
14/05/10

Mean = $1.874 \pm 0.003$
Sigma = $0.018 \pm 0.004$

Significance (2 $\sigma$) $7.1 \pm 1.5$
S ($2 \sigma$) $170.2 \pm 34.8$
B ($2 \sigma$) $402.2 \pm 14.4$

$M(K\pi\pi) - M(K\pi)$: $p_t > 3$ GeV/c

Entries/0.5 MeV/c²

Entries $\times 10^6$ chance

$D^- \rightarrow D^0 \pi_0$
ALICE work in progress
11/05/2010
$J/\psi \rightarrow e^+ e^-$

$J/\psi \rightarrow \mu^+ \mu^-$
Outlook for 2010

- $\pi^0, \eta$
- c and b production
- $J/\psi$ production
- high multiplicity
- jet correlations
- event shape
- underlying events
- reconstructed jets
- b-tagged jets
- ...

and of course...

- Pb-Pb!

... but John will tell you about that....
The fun has just started!!!